A COMPARATIVE STUDY BETWEEN PRIORITY ASSIGNING METHOD AND LAMBDA ITERATION METHOD FOR UNIT COMMITMENT PROBLEMS

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A COMPARATIVE STUDY BETWEEN PRIORITY ASSIGNING METHOD AND LAMBDA ITERATION METHOD FOR UNIT COMMITMENT PROBLEMS

A Thesis submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology in "Electrical Engineering"

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CERTIFICATE

This is to certify that the thesis entitled "**A Comparative Study Between Priority Assigning Method And Lambda Iteration Method for Unit Commitment Problems**", submitted **Mr. Chandan Bhardwaj, Roll No**: **109EE0034** and **Mr. Mayank Mishra, Roll No: 109EE0047** in partial fulfilment of the requirements for the award of **Bachelor of Technology** in **Electrical Engineering** during session 2010-2011 at National Institute of Technology, Rourkela. A bonafide record of research work carried out by them under my supervision and guidance.

The candidates have fulfilled all the prescribed requirements.

The Thesis which is based on candidates' own work, have not submitted elsewhere for a degree/diploma.

In my opinion, the thesis is of standard required for the award of a bachelor of technology degree in Electrical Engineering.

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ABSTRACT

Our project report basically focuses on the Unit Commitment Scheduling of Thermal power stations so as to obtain the most optimized way of power production fulfilling the total load requirements, transmission losses and at a same time integrating all the safety measures required. The Unit Commitment is a complex decision making process because of multiple constraints which may not be violated while finding the Optimal Commitment Schedule .This report also deals with the Economic Load Dispatch through Equal Incremental Cost of different operating units so as to have the most efficient and economical generation from different units with sufficient reserve capacity to meet any abnormal operating conditions. The goal of the objective function is in cost reduction ,so we use the economic dispatch using the lambda iteration method when we calculate the production cost. Methods for assigning priority to different generating units are also discussed in brief. Finally we wish to solve a load flow solution using Two Different Approaches and compare their result to get the most optimized way of generation and verify it using MATLAB.

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CHAPTER 1

UNIT COMMITMENT

1.1. INTRODUCTION, WHAT IS UNIT COMMITMENT (UC):

Unit Commitment, abbreviated as UC, refers to strategic choice to be made in way to determine which of the available power plants should be considered to supply power.

UC is not the similar to dispatching. Dispatching consists of fitting a given set of power plants into a certain power demand. UC decides the set of plants from which dispatching can be chosen. The difference between both issues occurs in time. In dispatching and allocating decisions, there is practically no time to rapidly start a power plant because the inertia of most plants will not allow this.

UC therefore prepares a set of plants and stipulates in which time period they have to be on-line and ready for dispatching. UC chooses plants taking into account a wide variety of parameters, technological aspects(such as minimum operating point, start-up and shut-down operation time and transient behavior) as well as economic considerations (such as start-up costs and operational costs) and social elements (such as availability of staff and work-schemes).However latter can be neglected sometimes.

UC optimization helps to minimize electricity generation costs.

1.2. APPLICATIONS OF UNIT COMMITMENT:

For utilities, UC is a problem that is to be solved in a time period of one day up to one week. The power systems these utilities need to optimize are usually limited to ten to fifty power plants. Most UC models have been developed for these types of utilities and therefore concentrate on short term UC of relatively smaller power systems.

In the broader context of energy, electricity or environmental modeling, however both the power systems and the time period considered are much larger. In such models (used for, e.g., the calculation of the emissions or the energy use of a country), UC is not the main objective. In order not to have a disproportional impact on the overall calculation time, a UC bottleneck in the model should be avoided. Therefore, a proper choice between accuracy and the utility of UC in the overall calculation time is to be made.

1.3 LITERATURE REVIEW:

In [1], Unit Commitment is a large scale short-term optimization problem, in which the major objective is to distribute and schedule generation to minimize the total fuel cost or to maximize the total profit or revenue over a study period, subject to a large number of constraints that must be satisfied.

In [2], the long-term fuel scheduling problem for optimizing the purchase cost, distribution, storage and utilization of fuel is considered. This problem can be designed as a large-scale linear optimization problem with the objective of minimizing the total fuel and hence the total cost.

In [3], the combined-cycled units have been increasingly installed throughout the world because of their high efficiency and fast response and the authors present a simplified combined-cycled unit model to efficiently solve the related mixed integer linear programming-based (LP) UC problem. By testing two arbitrary test systems, output show that the given model is effective to reduce the complexity of problem with losing little solution accuracy.

In[4], a heuristic algorithm based on the average full load cost (ALFC) without network constraints solution of unit commitment problem with network constraints using combination of heuristic algorithm and OPF. The suggested method has been applied to IEEE 118 test system with 36 generator over 24-period. The result shows that the proposed algorithm is capable to obtain satisfactory schedules without any constraint violation.

In [5] ,the new unit commitment method based on the de-commitment procedure provides a powerful tool for solving the power system resource scheduling and allocating problems. The two criteria proposed guarantee good performance with total system cost savings during each iteration. Another important application of this new method is in the improvement of already feasible schedules obtained through other methods such as LR, which are known to frequently result in over-commitment of units to satisfy capacity constraints and which is their major drawback.

In [6], In this model, author solves an hourly unit commitment problem, which studies space constraints of generation and transmission ,random equipment malfunction, and load forecasting difficulty into the reliability problem. He considers different possible uncertainties outcome while calculating the optimal reserve in the unit commitment solution as a tradeoff between minimizing operating costs and satisfying power system reliability requirements. Loss-of-load-expectation (LOLE) is included as a constraint in the stochastic unit commitment for calculating the cost of supplying the reserve.

In [7], the EPL method consists of two stages; in the first stage we get any initial unit commitment problem schedules by Priority List (PL) method. At this step, operational constraints are not taken into account. In the second stage unit schedule is changed using the problem specific heuristics to fulfill operational constraints.

In [8], the work done in this paper by using the forward dispatching, allocation modification and backward dispatching, a generation allocation which satisfies the spinning reserve requirement and the ramp rate limits are obtained. This schedule is automated by the future probabilistic reserve assessment to meet a given risk value. The optimum value of this risk index is selected based on the tradeoff between the total unit- commitment schedule cost and the expected cost of energy not served. Finally, a unit de-commitment technique is incorporated to solve the problem of reserve over-commitment in Lagrangian relaxation based unit commitment.

In [9] , Two-stage robust optimization formulation to address unit commitment problem in unit outages. The overall problem is solved by using two-level cutting-plane algorithm, which converges within reasonable time. The total cost under worst contingency over a selected uncertainty set is to be minimized, so the resultant decisions have good robust performance if the uncertainty set is appropriately defined. Besides the conventional ($n – K$) criterion, this paper provides a novel α-cut criterion that make use of the information of probability distributions to reduce the operating cost.

In [10], Load forecasting accuracy has significant impact to the cost saving of all utilities in the planning of energy supply. According to the recorded performance of Artificial Neural Network Short-term Load forecaster being utilized in a real operational environment, the temperature forecast error is observed to be the major cause of load forecast error. This paper describes the steps to develop an artificial neural network model (ANN) for short term load forecast and proposed the enhancement of STLF engine by the integration of front-end weather forecast model.

In [11], the multi-pass dynamic programming technique for the solution of the unit commitment and hydrothermal generation scheduling problem. The problem formulation is very complicated and is more complete than hydrothermal coordination. The algorithm is tested on Tai-power system with seven hydro generating units, one pumped storage plant and forty four thermal generating units. Solutions are reached within 40 minutes on a 16 MHz PC/AT and are consistent with engineering outcome. The satisfactory results, the rapid convergence and small memory requirement make the algorithm suitable for practical systems with many generation units.

In [12], a weekly hydro and thermal generation scheduling method including hydro-thermal unit commitment. The thermal unit commitment consists of the iteratively optimizing approach and the constraint processing algorithm by considering the hydro system operation. The hydro unit commitment is treated by the aggregation decomposition method and the Improved-Matrix Screening. The proposed approach does not determine a schedule at once in consideration of the complexity of the problem, but uses the following step:

(1) Decides the initial schedule by DP.

(2) Process the thermal unit operation constraint considering the hydro system operation.

(3) Process the violation of reservoir storage limit constraint by the Improved Matrix Screening.

In [13] , an iterative coordination of a Short-Term Unit Commitment (Day Ahead Scheduling - DAS) with a Stochastic Weekly Unit Commitment (SWUC) for the efficient scheduling of slow-start thermal units that caused due to random forced outages is presented. For the modeling and solution of the SWUC problem, 500 scenarios regarding the availability of the thermal units have been created and grouped in 11 scenario classes. The implementation of the proposed algorithm for a four–day period results in lower system total production cost as compared to the case where the DAS models run independently and consecutively, without the intermediate incorporation of the SWUC model solution.

In [14], the short term unit commitment often requires a method that is fast to meet system changes and reduces the scheduling errors. With a trained ANN model, a fast and direct assessment of LMP’s has been obtained. The numerical results obtained indicate that the present method provides an alternative for Unit Commitment practices.

In [15], a high accuracy of the load forecasting for power systems improves the security of the power system and reduces the generation costs, the next day load forecasting using ANN model with AR model firstly made for solving the UC problem, for 4-unit Tuncbilek thermal plant in Kutahya region, Turkey. LR method is used for solving the UC problem. Total costs are calculated for load data which is taken from Turkish Electric Power Company and Electricity Generation Company and forecasting load data computed by ANN model and ANN model with AR, separately. Comparing to these total costs show that load forecasting is important for UC. Furthermore, it is clear that the UC solution with the forecasting load is better than without one in terms of total cost.

In [16] ,a large scale Unit Commitment (UC) problem has been solved using Conventional dynamic programming (CDP), Sequential dynamic programming (SDP) and Truncation dynamic programming (TDP) without time constraints and the results show the comparison of production cost and CPU time. The UC provides a path to reduce the cost and improve reliability of the system. The Unit Commitment is a dynamic process, and the generating strategy is always changing according to different load and network topology.

CHAPTER **2**

ECONOMICS OF POWER GENERATION

2.1 ECONOMICS OF THE POWER GENERATION:

The function of a power station is to deliver power at the lowest possible cost per kilo watt hour. This total cost is made up of fixed charges consisting of interest on the capital, taxes, insurance, depreciation and salary of managerial staff, the operating expenses such as cost of fuels, water, oil, labor, repairs and maintenance etc. The cost of power generation can be minimized by:

1. Choosing equipment that is available for operation during the largest possible % of time in a year.
2. Reducing the amount of investment in the plant.
3. Operation through fewer men.
4. Having uniform design
5. Selecting the station as to reduce cost of fuel, labor, etc.

All the electrical energy generated in a power station must be consumed immediately as it cannot be stored. So the electrical energy generated in a power station must be regulated according to the demand. The demand of electrical energy or load will also vary with the time and a power station must be capable of meeting the maximum load at any time. Certain definitions related to power station practice are given below:

Load curve: Load curve is plot of load in kilowatts versus time usually for a day or a year.

Load duration curve: Load duration curve is the plot of load in kilowatts versus time duration for which it occurs.

Maximum demand: Maximum demand is the greatest of all demands which have occurred during a given period of time.

Average load: Average load is the average load on the power station in a given period (day/month or year)

Base load: Base load is the minimum load over a given period of time

Peak load: Peak load is the maximum load consumed or produced by a unit or group of units in a stated period of time. It may be the maximum instantaneous load or the maximum average load over a designated interval of time.

2.2 THERMAL GENERATION:

Thermal units provide a well-coordinated generation schedule to meet the power demand in the most optimized effective and economical way. Generally the generation from thermal units is kept constant at some particular base value and generation from different hydro units is varied according to the load fluctuations as it is more easy to control hydro power and higher response rate then thermal generating units.

Objective function

Thermal coordination is to find the optimal generating schedule of each unit so that the total system production cost is minimum over the time range under schedule. Therefore the objective functions can be expressed as follows:

Minimize $C = \sum_{j=1}^{j_{max}} n_j \sum_{i=1}^{N_j} C_i\left(PF_{ij}\right)$ ………………….. (2.1)

Where

C: the total system production cost

n_j:number of hours at the j^{th} time interval

C_i: the cost function of i^{th}thermal unit

PF_{ij}:the genration output of the ith thermal unit at the j^{th} time stage

N_j:the number of thermal units committed at the j^{th} time interval

j_{max}:maximum number of time stages

The cost functions of thermal generation units are expressed as second order polynomial.

$C_i = C0_i + C1_i * PF_{ij} + C2_i * PF_{ij}^2$……………………………………………….(2.2)

$C0_i$, $C1_i$ and $C2_i$ are constants.

2.3 CONSTRAINTS:

The short term Thermal coordination problem must meet the following constraints

1.Power balance

At each time stage total generation must equal the sum of the system load and transmission losses.

$$\sum_{i=1}^{N} PF_{ij} + \sum_{i=1}^{M} PH_{ij} = PL_j + PT_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.3)}$$

PH_{ij}: the generation output of the i^{th} hydro unit at the j^{th} time stage

PL_j: the power system load at j^{th} time stage

PT_j: the transmission losses at the j^{th} time stage

M: the number of hydro units

2 .Generation units:

In order to avoid damaging generation units and to operate generation units at high efficiency range, the generation output must be limited as follows:

$$PF_{i,min} \leq PF_{ij} \leq PF_{imax} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.4)}$$

$$PH_{imin} \leq PH_{ij} \leq PH_{imax} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.5)}$$

PH_{imin}: the minimum generation of the i^{th} hydro unit

PH_{imax}:the maximum generation of the i^{th} hydro unit

PF_{imin}: minimum generation of i^{th} thermal unit

PF_{imax}: maximum generation of i^{th} thermal unit

3. Available water limits:

The available water at each hydro unit is limited by the reservoir natural inflow and operation curve:

$$\sum_{j=1}^{j_{max}} n_j * q_{ij} = q_{i,tot} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.6)}$$

$$q_{i,max} \leq q_{i,tot} \leq q_{i,max} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.7)}$$

q_{ij}: the discharge of the i^{th} hydro unit at the j^{th} time stage

$q_{i,tot}$: the total available water volume of the i^{th} hydro unit over the whole scheduling time range

$q_{i,min}$: the minimum discharge of the i^{th} hydro unit

$q_{i,max}$: the maximum discharge of the i^{th} hydro unit

4. Generation change rate limits:

Because of the physical limits of thermal unit's structures, the rates of generation change must be limited within certain range. The response of hydro units is fast enough that their change rate can be neglected. The change rate of thermal units is limited as follows:

$$|U_{ij}| \leq U_{i,max} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.8)$$

$$|U_{ij}| = PF_{i,j+1} - PF_{i,j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.9)$$

U_{ij}: the ith thermal unit change rate at the j^{th} time stage

$U_{i,max}$: the maximum change rate of the i^{th} thermal unit

CHAPTER **3**

METHODS OF UNIT COMMITMENT

3.1 METHOD OF EQUAL INCREMENTAL OF PRODUCTION COST :

3.1.1 INTRODUCTION: The economic load dispatch problem is defined as

$$Min\ F_T = \sum_{n=1}^{N} F_n \text{.............................. (3.1)}$$

$$\text{Subjected to } P_D = \sum_{n=1}^{N} P_n \text{..................(3.2)}$$

Where: F_T : Total Fuel Input to the system.

F_n : The fuel input to the n^{th} unit.

P_D : Total power demand.

P_n : The generation from n^{th} unit.

By making use of the Langrangian multiplier the auxiliary function is obtained as:

$$F = F_T + \lambda\ (P_D - \sum_{n=1}^{N} P_n) \text{............(3.3)}$$

Where: λ is the langrangian multiplier.

Differentiating F with respect to the generation P_n and equating to zero gives the condition for optimal operation of the system.

$$\frac{\partial F}{\partial P_n} = \frac{\partial F_T}{\partial P_n} + \lambda\ (0\text{-}1) = 0 \text{.......................,.(3.4)}$$

$$= \frac{\partial F_T}{\partial P_n} - \lambda = 0.$$

Since $F_T = F_1 + F_2 + \ldots\ldots + F_n$ ....(3.5)

Therefore condition for optimum operation is

$$\frac{dF_1}{dP_1} = \frac{dF_2}{dP_2} = \text{................} = \frac{dF_n}{dP_n} = \lambda.\ \text{.....................(3.6)}$$

Where: $\frac{dF_n}{dP_n}$ = incremental production cost of plant ‘n’.

3.1.2 A MAJOR SETBACK TO THIS METHOD:

As we know, the fuel cost characteristic of any generating unit takes a differential form as follows :

$$F = A + (B^*P) + (C^*P^2). \ldots\ldots\ldots\ldots (3.7)$$

$$P_{min} \leq P \leq P_{max} . \ldots\ldots\ldots\ldots (3.8)$$

Where: F = total production cost.

P = total power generated from that unit.

A= Fixed production cost constant.

B, C = variable production cost constant.

P_{max} = Maximum generation that can be obtained from that unit.

P_{min} = Minimum generation from that unit.

Now as we know from the method of Equal Incremental of Production cost, for optimum production cost, rate of generation from each unit in a system has to be same. When we differentiate the cost function and equate that differentiated function to lambda 'λ', we get the equation as follows:

$$B + (2 * C * P) = \lambda. \ldots\ldots\ldots\ldots (3.9)$$

Since every generating unit is associated with a Minimum and Maximum generation limit, there is also a limit defined for the value of 'λ' for each generating unit corresponding to $\lambda_{min} \leq \lambda \leq \lambda_{max}$.

Where :

$$\lambda_{max} = B + (2^*C^*P_{max}) \ldots\ldots\ldots\ldots (3.10)$$

$$\lambda_{min} = B + (2^*C^*P_{min}) \ldots\ldots\ldots\ldots (3.11)$$

Now for application of Method of Equal Incremental, each generating unit in a plant should have an overlapping range of values of 'lambda', which in most of the cases is not possible as any generating plant consists of several unit having different generation limits. Any value of 'lambda' not lying in the specified range for that particular unit will lead to allocation of power which will be deviated from the given range of power generation capability of that unit. So in all those cases it will be difficult to implement this Method of Equal Incremental. This is one of the major setbacks of Equal Incremental Production Cost method.

3.2 A MODIFIED APPOACH TO METHOD OF EQUAL INCREMENTAL:

*3.2.1 INTRODUCTION***:** In this modified approach, we will be performing 'n' no iterations for having the final allotment of power through various generating units where 'n' is the total no of generating units involved for the Generation of that particular Demand.

In each iteration we will be calculating the value of 'lambda' satisfying the total load demand for that iteration. Corresponding to that 'lambda' value, we will be calculating power allotted to each generating unit.

$$P_n = (\lambda - B) / (2 * C); \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.12)$$

$$\sum_{n=1}^{N} P_n = \text{Demand}. \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.13)$$

This first iteration is exactly same as that of the Method of Equal Incremental of Production Cost. Now knowing the power allotted to different generating units, we will be calculating the total cost incurred from each generating unit corresponding to their respective cost functions.

Suppose at the end of First iteration,

let power allotted to different units be G_1, G_2, ……… , G_n .

and corresponding cost be P_1, P_2, …………, P_n.

Since our main aim is to minimize the total cost of production, from the various cost (P_1, P_2,……, P_n) that we obtained, we will consider the unit having the minimum cost. [Minimum (P_1, P_2,……, P_n)]. Let that be any p^{th} unit. For that unit we will see what was the power allotted initially (G_p). If this power is within the limits of generation of that p^{th} unit, than we will fix the generation from that unit at G_p. Now for the next iteration, number of units will be (n-1) and total demand will be (Demand - G_p).

However, if G_p does not fall in the specified range of power generation, than following alteration will be made to the value of G_p .

If $G_p > G_{pmax}$: (which means for most economical production, generation from that p^{th} unit should be maximum) : so in this case, we will set $G_p = G_{pmax}$. So for next iteration,

New Demand = Initial Demand-G_{pmax}

If G_p < G_{pmin} : (which means for most economical production, Generation from that p^{th} unit should be minimum) : so in this case, we will set G_p = 0. So for next iteration,

New Demand = Initial Demand.

After the first iteration is over, we will perform the other iterations in the same way as before but with new Demand and reduced no of Generating units.

Iterations will continue till each generating unit has been assigned a particular power demand.

3.2.2 ADVANTAGE OF THIS METHOD:

With this new modified approach whatever be the size of the plant, whatever be the no of generating units and whatever be the range of power generation of each unit, we can easily find the most optimized way to allocate power among all the units with all the allocated power lying in the specified range for each generating unit.

Problem of over-exhausting any unit by producing more than its specified level and also problem of under-production from any unit is eliminated by this method as both the above circumstances not only leads to more losses but also leads to continuous deterioration of generating units.

3.2.3 DRAWBACK OF THIS METHOD:

If we are considering for a station with large number of generating units, than for allocation of power to each unit, number of iterations required will be more. For ‘n’ number of units we will be performing ‘n’ no iteration with each iteration consisting of finding suitable ‘lambda’ satisfying the total demand for that iteration. Since finding value of ‘lambda’ itself is too time consuming task, the total time required for the final allocation of power will be very large as compared to that of Original Equal Incremental Production Cost Method.

Also, while calculating the value of ‘lambda’, we always consider a particular deviation from the actual demand i.e. total demand associated with any particular ‘lambda’ value will deviate from original demand by small amount (± some % of actual Demand). Since in this method, in each iteration we are calculating new value of ‘lambda’, the total variation in the power Generated to that of the total Demand is found to be somewhat more than that with Original Equal Incremental Production Cost Method.

3.2.4 In [17],FLOWCHART REPRESENTATION MODIFIED EQUAL INCREMENTAL METHOD

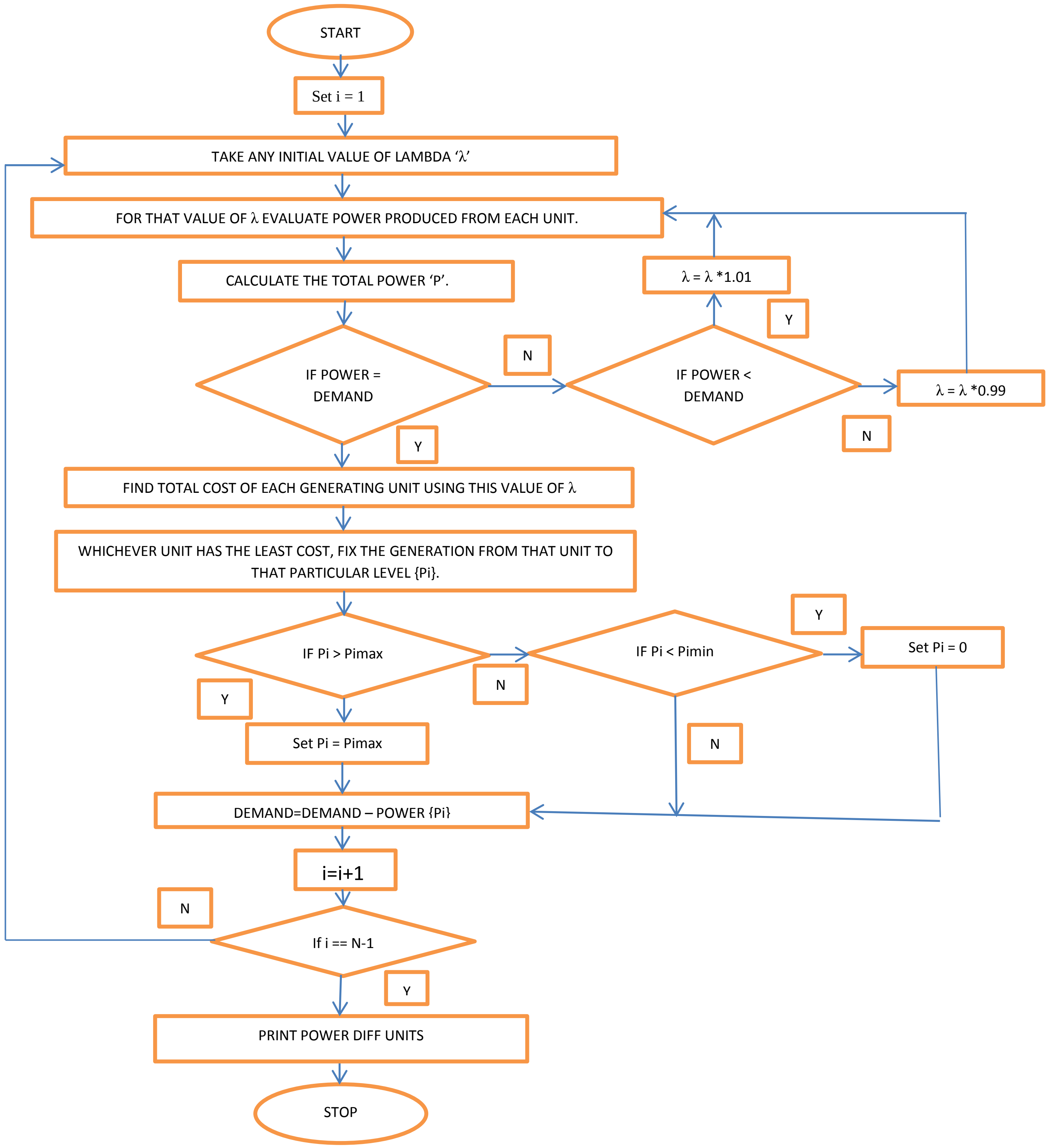


Fig 3.1: Flowchart representation of Modified Equal Incremental Production Cost Method

3.3 LAMDA ‘λ’ ITERATIVE METHOD:

3.3.1 HIT AND TRIAL METHOD: In this Method, we will initially take any value of lambda. For that value of ‘lambda’ we will calculate power from each of the generating unit.

P_n = (λ – B) / (2 * C); ……………………………………(3.14)

Let P = $\sum P_n$. ………………………………………………(3.15)

For any Total Demand “D” -

if P>D – than we will decrease the value of ‘lambda’ by .99 i.e. λ = λ*0.99.

if P<D – than we will increase the value of ‘lambda’ by 1.01 i.e. λ = λ *1.01.

Than with this new value of ‘lambda’, we will again calculate the total power and repeat the above steps till we get a definite value of λ satisfying the load demand.

3.3.2 REGULAR FALSI-METHOD: In this method, we will take two initial values of ‘lambda’ (λ_1 *and* λ_2). For both these values of ‘lambda’ we will calculate total power from each of the units as above –

P_n = (λ – B) / (2 * C);

Let P = $\sum P_n$.

For any load demand ‘D’, we define error ‘e’ as e = (D – P).

The initial values of ‘lambda’ should be chosen such that for one ‘lambda’ value we will get a positive (+ve) error (e_1) and for the other we get a negative (-ve) error (e_2). This clearly means that desired value of ‘lambda’ lies between these two limits. For getting the desired value of ‘lambda’, we will apply the formula for regula-falsi method i.e.

$$\lambda = \frac{(\lambda_1 * e_2) - (\lambda_2 * e_1)}{e_2 - e_1} \; . \; ....(3.16)$$

Now for this value of 'lambda', we will calculate power from each unit and hence the total power (P_1). Than we will calculate the error (e_3).

If $e_3 > 0$ i.e. (+ve), than $\lambda_1 = \lambda$

If $e_3 < 0$ i.e. (-ve), than $\lambda_2 = \lambda$.

With this new values of (λ_1 *and* λ_2) we will again calculate the total power and again new value of 'lambda' till we don`t get a that value of 'lambda' for which error is zero or within certain acceptable limit.

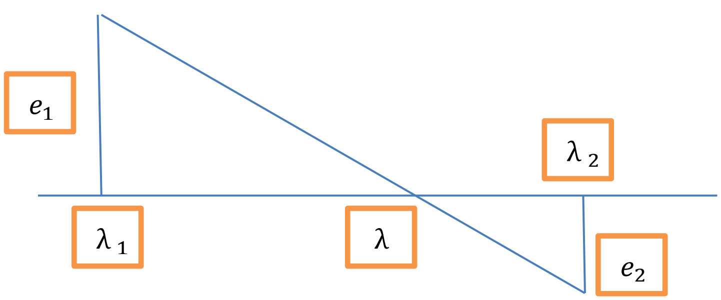


Fig 3.2 : Lambda iteration by Regula-Falsi Method

λ_1 and λ_2 corresponds to the two initial approximated values of Lambda such that error for 1 is positive and other is negative and from the two values we are estimating the real value of Lambda

3.4 PRIORITY LIST APPROACH FOR ECONOMIC LOAD DISPATCH:

3.4.1 INTRODUCTON: This method is considered to be one of the simplest method of unit commitment scheduling. This method consists of creating a priority list of all the generating units based on their Average Full Load Cost (AFLC) value. Unit with the least value of AFLC is assigned the top most priority and the rest according to the increasing value of AFLC.

This method is primarily based on the principle that unit with the least value of AFLC should be loaded to the maximum level and the unit with the least value should be lightly loaded as this may fetch more economical unit commitment solution.

The value of AFLC is calculated as follows :

$$\mathrm{AFLC_i} = \frac{\mathrm{A_i} + (\mathrm{B_i} * \mathrm{P_{imax}}) + (\mathrm{C_i} * \mathrm{P_{imax}^2})}{\mathrm{P_{imax}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(3.17)$$

Following steps are followed for having unit commitment through Priority List Method –

- According to the AFLC value, arrange each generator in increasing order of their AFLC values. Generator with least value is given the highest priority.
- Now according to the total demand ‘D’, select how many generators required to fetch the given demand i.e. $\sum P_{max}$ of how many generators from top are giving the required Demand.
- If number ‘n’ comes out to be one, than entire generation from that priority 1 unit.
- If ‘n’ comes out to be two, than through exhaustive technique checking which combination of power distribution between the two units is fetching the most optimized result.
- If ‘n’ is coming greater than two, than all the generators from 1 to (n-2) will be loaded to their full capacity. The power left after loading these (n-2) generators will be distributed between the two left generators and through exhaustive technique, we will find the most optimized way to distribute the remaining power between these two units.

3.4.2 In [17],FLOWCHART REPRESENTATION OF PRIORITY LIST METHOD:

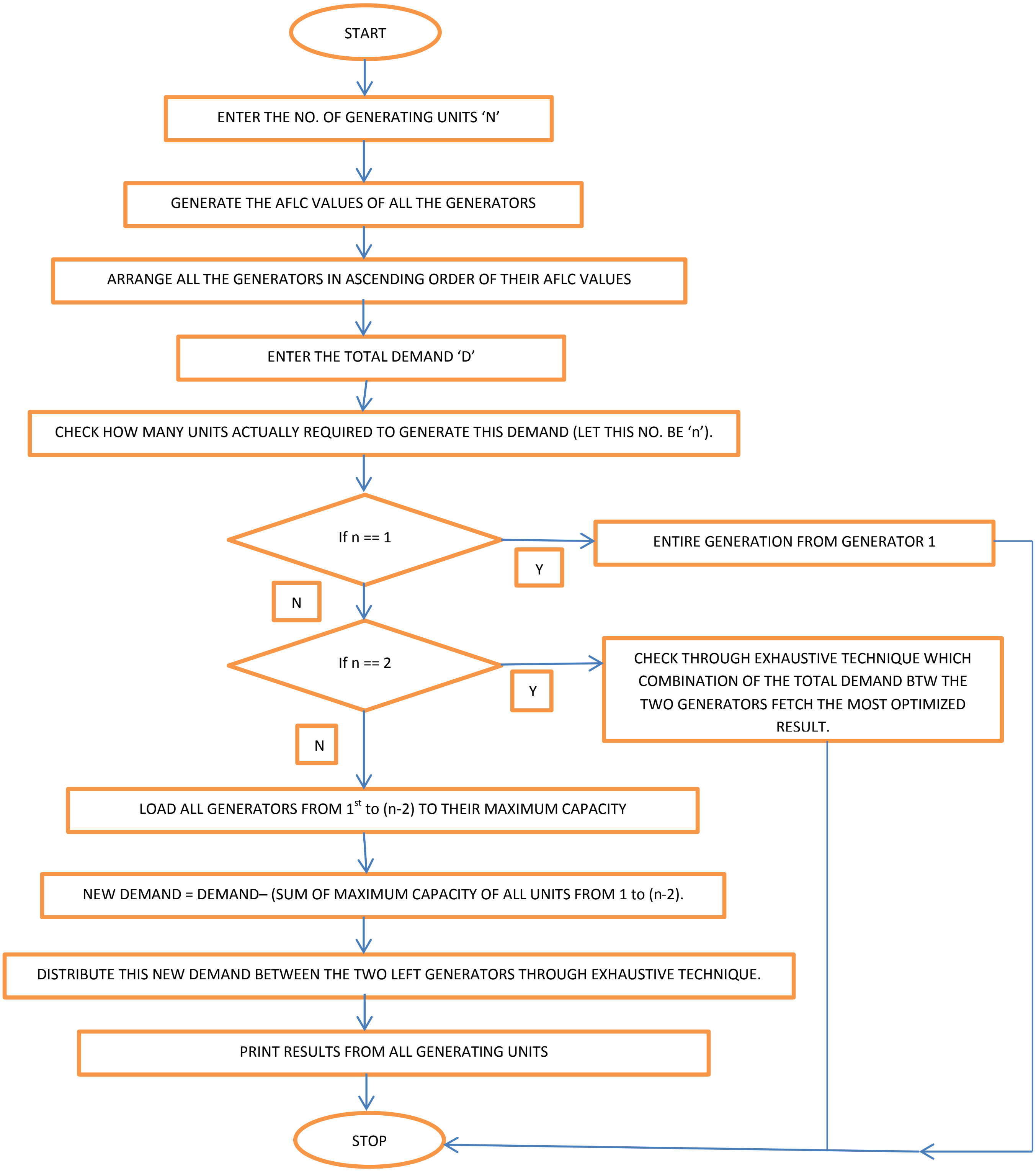


Fig 3.3: Flow Chart representation of Priority Assigning Method

CHAPTER **4**

RESULTS AND DISCUSSIONS

4.1 LOAD CURVE:

For the comparison of the above two methods, we will be considering the following load curve having its day long variations as follows:-

Table 4.1: Load Demand at different hours in a day

Time (h)	Load (MW)		Time(h)	Load (MW)
1	330		13	810
2	450		14	820
3	480		15	750
4	360		16	800
5	520		17	650
6	590		18	670
7	730		19	790
8	780		20	750
9	620		21	770
10	650		22	610
11	680		23	520
12	630		24	360

The table above shows the Net Demand occurring during various hours in a day

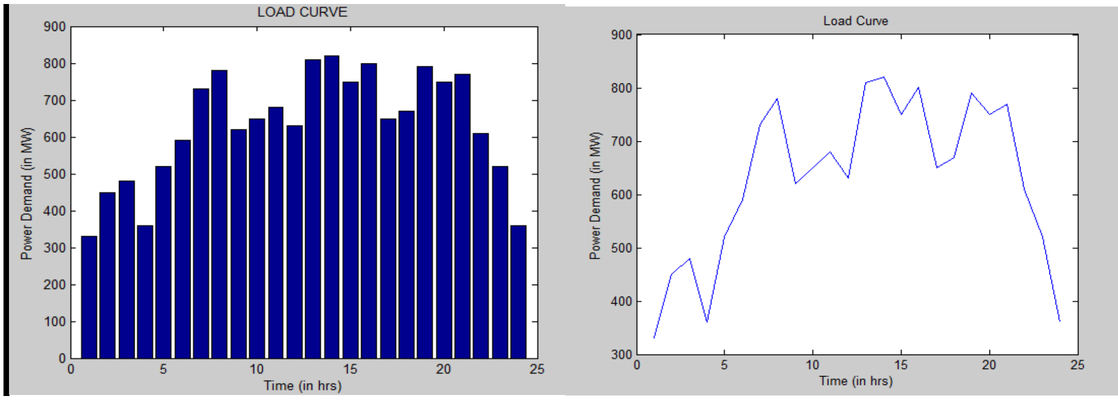


Fig 4.1: Load Variation (in MW) over a period of 24 hrs.

The above curve shows the variation in the Load Demand Occurring during the various hours in a day. This Load Curve has been used as a reference for the development of Unit Commitment Model for Modified Equal Incremental Production Cost Method and Priority Assigning Method and to have a comparative study between the two Methods.

4.2 UNIT CHARACTERISTICS:

For performing our simulations, we will be using a 5 unit system having the following characteristics:-

Table 4.2: Specifications of Different Generating Units

Parameters	**Unit1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**
Minimum Output	500	150	150	210	500
Maximum Output	150	20	20	80	190
A	.00048	.00045	.0004	.00043	.0005
B	16.19	16.38	16.39	16.25	16.20
C	1000	700	680	750	950

The table describes the characteristics of the different generating units employed along with the minimum and maximum generation level that can be obtained from each generators.

4.3 RESULTS OBTAINED BY THE MODIFIED EQUAL INCREMENTAL PRODUCTION COST (METHOD 1):

Table 4.3: Load Distribution according to Modified Equal Incremental Production Cost Method

Hr	1	2	3	4	5		Hr	1	2	3	4	5
1	330	0	0	0	0		13	253.09	58.07	53.84	210	233.91
2	327	0	0	122.316	0		14	257.445	60.79	55.89	210	235.55
3	347	0	0	132.08	0		15	241.229	46.19	40.36	199.511	220.77
4	270	0	0	89.088	0		16	266.225	66.27	62.06	210	243.77
5	371	0	0	148.026	0		17	227.36	30.71	0	183.303	207.64
6	218.393	0	0	172.799	198.607		18	226	30.71	22.05	183.303	206
7	238.514	42.54	35.36	194.751	217.486		19	248.018	54.42	48.72	208.118	228.98
8	247.303	52.59	46.67	206.209	225.697		20	241.229	46.19	40.36	199.511	220.77
9	219.752	23.39	0	175.647	200.248		21	244.945	50.77	44.62	204.299	224.05
10	227.36	30.71	0	183.303	207.64		22	217.393	20.67	0	172.799	198.60
11	228.36	32.53	24.10	185.21	207.64		23	371	0	0	148.026	0
12	222.112	26.14	0	178.521	201.888		24	270	0	0	89.088	0

The Table above shows the variation in the total production from each of the units at different point of time. Some units are kept ideal for some time while some are utilized through the day.

4.3.1 GENERATION GRAPHS OF VARIOUS GENERATORS:

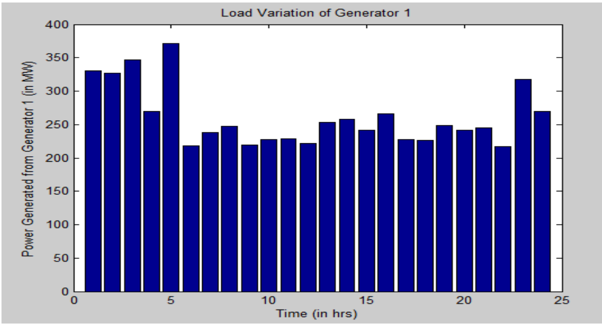


Fig 4.2: Load Variation of Gen 1

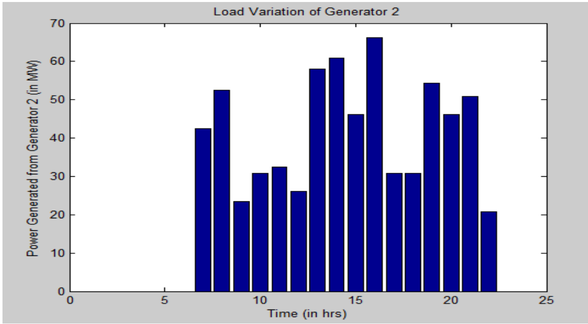


Fig - 4.3: Load Variation of Gen 2.

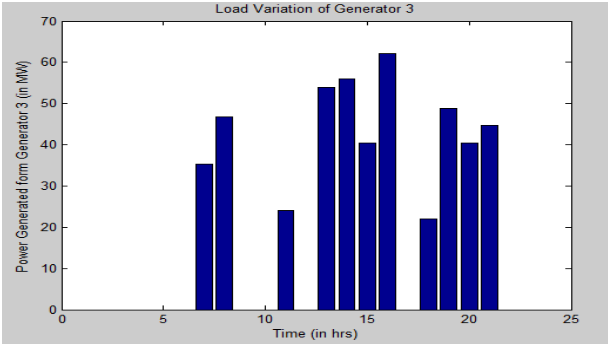


Fig 4.4: Load Variation of Gen 3

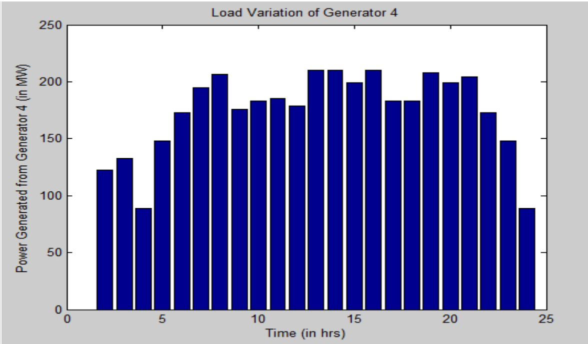


Fig 4.5: Load Variation of Gen 4

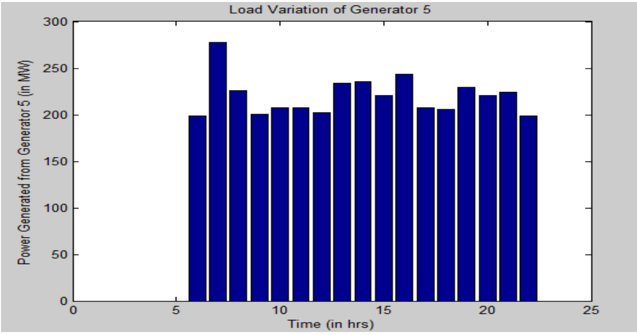
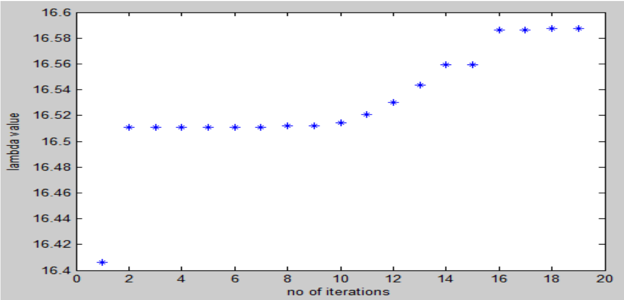


Fig 4.6: Load Variation of Gen 5

Variations in the generations from different generators at different point of time.

As can be seen from the above figures, all Generating Units are not made to work all the time. For smaller Load Demand, total requirement is meant through few units only and for larger demand, all units are made engaged.

4.3.2GRAPH SHOWING THE VARIATION OF LAMDA



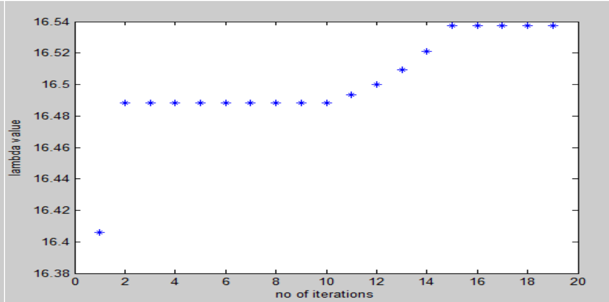
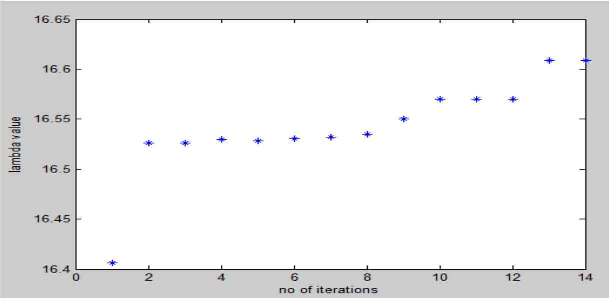


Fig 4.7: Lambda Variation for D=5000 & G =20

Fig 4.8: Lambda Variation for D=4500 & G=20



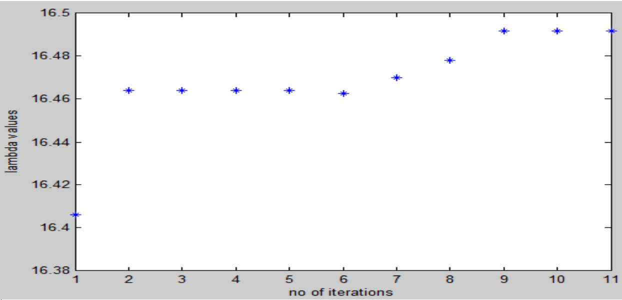
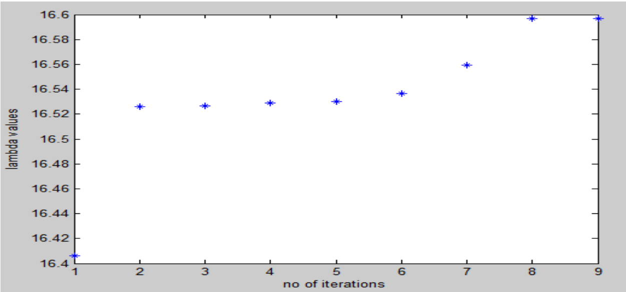


Fig 4.9: Lambda Variation for D=4000 & G =15

Fig 4.10: Lambda Variation for D=2500 & G=12



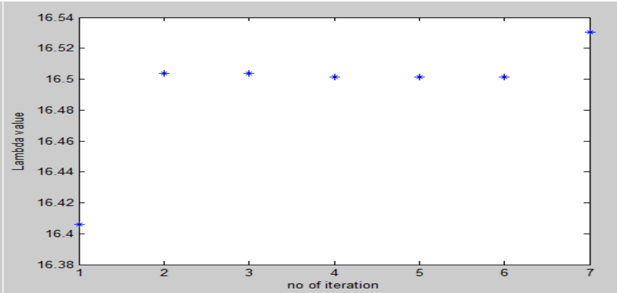


Fig 4.11: Lambda Variation for D=2760 & G =10

Fig 4.12: Lambda Variation for D=1800 & G=8

Variation in the value of Lambda for Different Combination of Power Demand (D) and No of Generating Units (G).

Above figure shows the variation in the lambda value for different iterations. As can be seen, for the iterations where the generation from each unit is within their prescribed limits, the lambda value is remaining constant for the next iteration also. Change in the Lambda value from that of the previous iteration indicate that some unit has crossed its prescribed limit of generation and is made to work at its maximum demand or at no generation level.

4.4 RESULTS OBTAINED FROM THE PRIORITY ASSIGNING METHOD (METHOD 2):

Table 4.4: Load Distribution according to Priority Assigning Method

Hr	1	2	3	4	5		Hr	1	2	3	4	5
1	330	0	0	0	0		**13**	418.801	0	0	0	391.19
2	450	0	0	0	0		**14**	423.601	0	0	0	396.39
3	480	0	0	0	0		**15**	388.402	0	0	0	361.598
4	360	0	0	0	0		**16**	414.001	0	0	0	385.99
5	271.203	0	0	0	248.799		**17**	337.602	0	0	0	312.398
6	306.803	0	0	0	283.198		**18**	347.602	0	0	0	322.398
7	378.502	0	0	0	351.998		**19**	408.801	0	0	0	381.19
8	404.001	0	0	0	375.999		**20**	388.402	0	0	0	361.598
9	321.603	0	0	0	298.397		**21**	398.402	0	0	0	371.598
10	337.602	0	0	0	312.398		**22**	316.803	0	0	0	293.198
11	352.802	0	0	0	327.198		**23**	271.203	0	0	0	248.799
12	326.803	0	0	0	303.197		**24**	360	0	0	0	0

Above table shows the variation in power generated from different units as per Priority Assigning Method

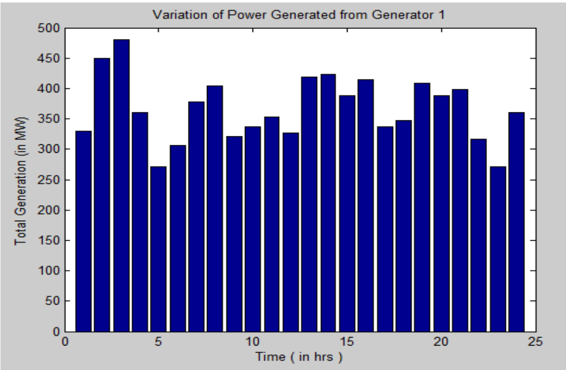


Fig 4.13: Load Variation of Gen 1

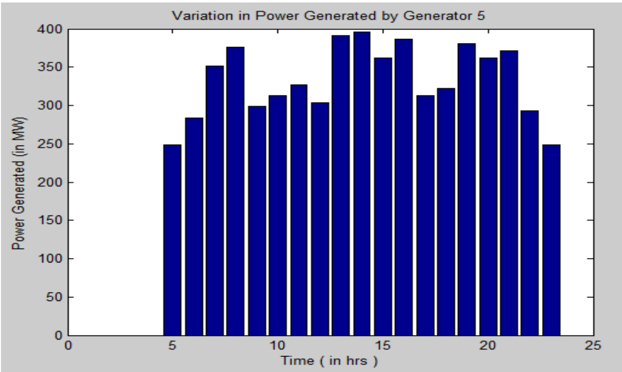


Fig 4.14: Load Variation of Gen 5

As can be seen, only two units are used through the day for the production of the overall demand. Total Demand is met by the two units having the top priority according to their AFLC values. Since only two units are used therefore the overall cost is also reduced as fixed cost of all the other units is not considered.

4.5 COMPARATIVE STUDY:

The Total Cost incurred in the production of desired power at a particular point of time is shown as follows:-

Table 4.5 Total Cost incurred by both the Methods: Modified Equal Incremental Production Cost Method (Method 1) and Priority Assigning Method (Method 2)

Time (in h)	**Load (in MW)**	**Total Cost-Method 1**	**Total Cost-Method 2**		**Time (in h)**	**Load (in MW)**	**Total Cost-Method 1**	**Total Cost-Method 2**
1	330	6394.97	6394.97		**13**	810	17292.8	15228.5
2	450	9089.52	8382.7		**14**	820	17469.9	15394.5
3	480	9591.31	8881.79		**15**	750	16293.3	14233.9
4	360	7607.38	6890.61		**16**	800	17940.8	15062.6
5	520	10237.4	10437.57		**17**	650	13987.7	12580.1
6	590	12316.1	11590.28		**18**	670	14980.1	12910.6
7	730	15974.7	13902.76		**19**	790	16953.6	14896.8
8	780	16792.6	14731.2		**20**	750	16293.3	14233.9
9	620	13496	12084.9		**21**	770	16632	14565.2
10	650	13987.7	12580.1		**22**	610	13339.1	11920
11	680	15140.5	13075.7		**23**	520	10237.4	10437.6
12	630	13653.8	12250		**24**	360	7607.38	7840.61

The above Table shows the comparision between the total cost incurred during the production of required demand through various generator by both the Methods. In most of the cases Priority Assgning Method is found to be more economical than Modified Equal Incremental Production Cost Method

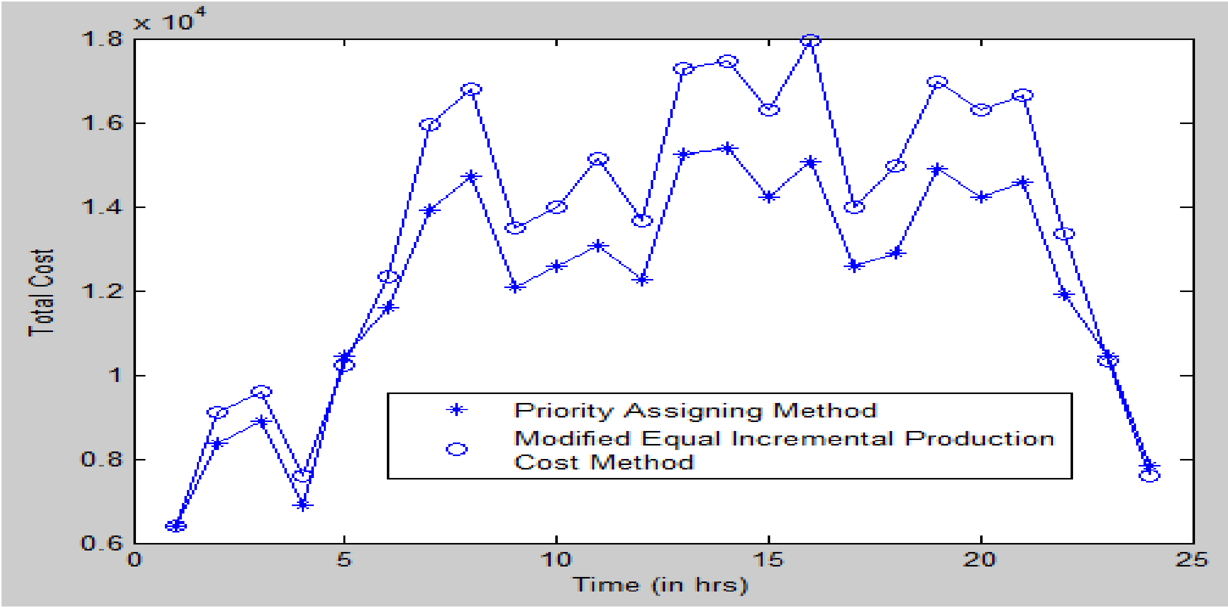


Fig. 4.15: Comparison in the total cost incurred by both the methods.

The above figure shows the comparison in the total cost incurred during the production of the required demand. As can be seen, for most of the points in the curve, Priority Assigning Method is shown to have fetched the minimum cost among both the Method. But still there are points in the curve where Modified Equal Incremental Production Cost Method has come out with more Optimum result. For lower value of the Demand, the difference between the total cost has a lower than that at higher Demand. Also for Demand where no of operating units has come out to be two for Modified Equal Incremental Production Cost Method, the overall total cost is minimum with this method only rather than Priority Assigning Method.

CHAPTER **5**

CONCLUSIONS

5.1 CONCLUSIONS

- Total Cost incurred during the generation of the required demand was obtained for both the methods i.e. Modified Equal Incremental Production Cost Method and Priority Assigning Method.

- For maximum cases of power requirement, Priority Assigning Method was found to give more optimized result in term of Total Cost than Modified Equal Incremental Production Cost Method.

- However, for certain cases, involving low power demand, Modified Equal Incremental Production Cost Method were found to be better than Priority Assigning Method.

- Number of Units Operating for fulfilling a specific Load Demand was found to be more in case of Modified Equal Incremental Production Cost Method.

- Since the no. of units are coming to be more, so the Fixed Cost of all the generating units adds up to give an overall more Total Cost for Modified Equal Incremental Production Cost Method than Priority Method.

- Variations in the value of Lambda for different iterations were obtained and were found to vary considerably between successive iterations.

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